FOREST PEST MANAGEMENT

BIOLOGICAL EVALUATION
R2-91-01

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IN SCORCHED AND GREEN TREES
2 YEARS FOLLOWING THE
CLOVER MIST FIRE
ON THE CLARKS FORK RANGER DISTRICT
SHOSHONE NATIONAL FOREST, WYOMING

United States
Department of
Agriculture

Forest Service

Forest Pest Management
Denver, Colorado

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ABSTRACT

In 1990, Douglas-fir beetle (DFB), Dendroctonus pseudotsugae Hopkins spread from Douglas-firs blackened by the 1988 Clover Mist Fire to partially scorched and green trees on the Clarks Fork Ranger District, Shoshone National Forest in northwestern Wyoming. Adult DFB began emerging in early May and peaked during June. Scorched trees were attacked first and green trees were selected generally after mid-June. A mean of 20 DFB emerged per 36 sq. in. of heavily-infested bark surface.

Total brood production in fall bark samples taken at 5-7 ft. was high, averaging 28 DFB per 36 sq. in., and represents a 1.5- to 2-fold increase in brood density from fall 1989. In addition to new (callow) adults, larvae and pupae were abundant in many samples, especially those from trees that were attacked later during the summer, i.e., green and scorched trees located farthest from the fire boundary. Densities of new adults averaged 14 per 36 sq. in. for all samples, and ranged from a mean of 10 per 36 sq. in. at Camp Creek (all green trees) to 26 per 36 sq. in. at Cathedral Cliffs (scorched trees near fire boundary). No unsuccessful egg galleries filled with pitch were present in samples. Gallery starts and total gallery length per 36 sq. in. area averaged 1.8 and 20 in., respectively. About 8 DFB were produced per attacking female by fall. Few parasites and predators were detected. Height of DFB attack averaged 34 ft and is estimated to be 2-3.5 times the bole height attacked in 1989.

The DFB population can be expected to increase at least 4-5 times from 1990 to 1991. Management alternatives to reduce the impact of the DFB epidemic are discussed and prompt salvaging of infested trees is recommended where feasible.

INTRODUCTION

During August 1988, the catastrophic Clover Mist Fire entered the Shoshone National Forest in Wyoming from Yellowstone National Park, sweeping across much of the North Absaroka Wilderness and into the Clarks Fork Ranger District, generally south of U.S. Highway 212 and Wyoming Route 296 (Forest Route 100). The hot, wind-driven fire destroyed extensive acreages of mixed conifer stands, composed predominately of lodgepole pine (Pinus contorta Dougl. ex Loud.), Engelmann spruce (Picea engelmannii Perry ex Engelm.), and Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco).

During visits to burned areas in summer and fall of 1989, entomologists determined that large numbers of the Douglas-fir beetle (DFB), Dendroctonus pseudotsugae Hopkins

(Coleoptera: Scolytidae), were present in large-diameter, blackened Douglas-fir trees (Pasek, 1990). Although half the bark samples (6 in. by 6 in.) from infested trees contained no DFB brood, average brood production was 9 and 7 callow adults per sample, respectively, at Cathedral Cliffs and Squaw Creek. On the basis of these numbers and the availability of large numbers of large-diameter ($\geq$ 10 in. DBH) fire-damaged and green Douglas-fir trees, an increase in the DFB population was predicted for 1990. Nearly pure stands and pockets of dense, mature or overmature Douglas-fir occur in areas near the fire boundary within the suitable timber base on the Clarks Fork Ranger District; Douglas-fir stands average more than 120 years of age and trees are nearly 200 years old at Cathedral Cliffs.

Observations during summer 1990 indicated an epidemic of DFB was developing in scorched and green Douglas-fir adjoining the fire boundary and in small pockets located at relatively short distances from the fire boundary. In mid-June, nearly all scorched Douglas-fir greater than 9 in. DBH with green crowns that were examined had been attacked by DFB. Degree of scorch did not appear to be a factor in predisposing trees to attack, since trees with root scorch only were infested as readily as trees scorched to a height of several feet. Furniss (1965) reported that any degree of fire injury makes Douglas-fir susceptible to DFB attack. By early August, as many or more green trees (no scorch) as scorched trees had been attacked by DFB. Approximately 2000 trees were thought to be infested on the Clarks Fork Ranger District in 1990. Infestations were detected at Sugarloaf Mountain, Camp Creek, Upper-Reef Creek, Cathedral Cliffs, Squaw Creek, Russell Peak, and Pahaska Tepee on the North Fork of the Shoshone River (Wapiti Ranger District). Most, if not all, areas of large-diameter Douglas-fir adjacent to burned areas likely were infested by DFB in 1990. Figures 1 and 2 illustrate the areas of burned trees and Douglas-fir habitat and known areas of DFB.

The purposes of this evaluation were to determine when adult DFB flight occurred in 1990, assess the population levels of DFB at Cathedral Cliffs and Camp Creek, and determine the potential for population increase in 1991.

CF DISTRICT DOUGLAS–FIR STANDS AND CLOVER MIST FIRE

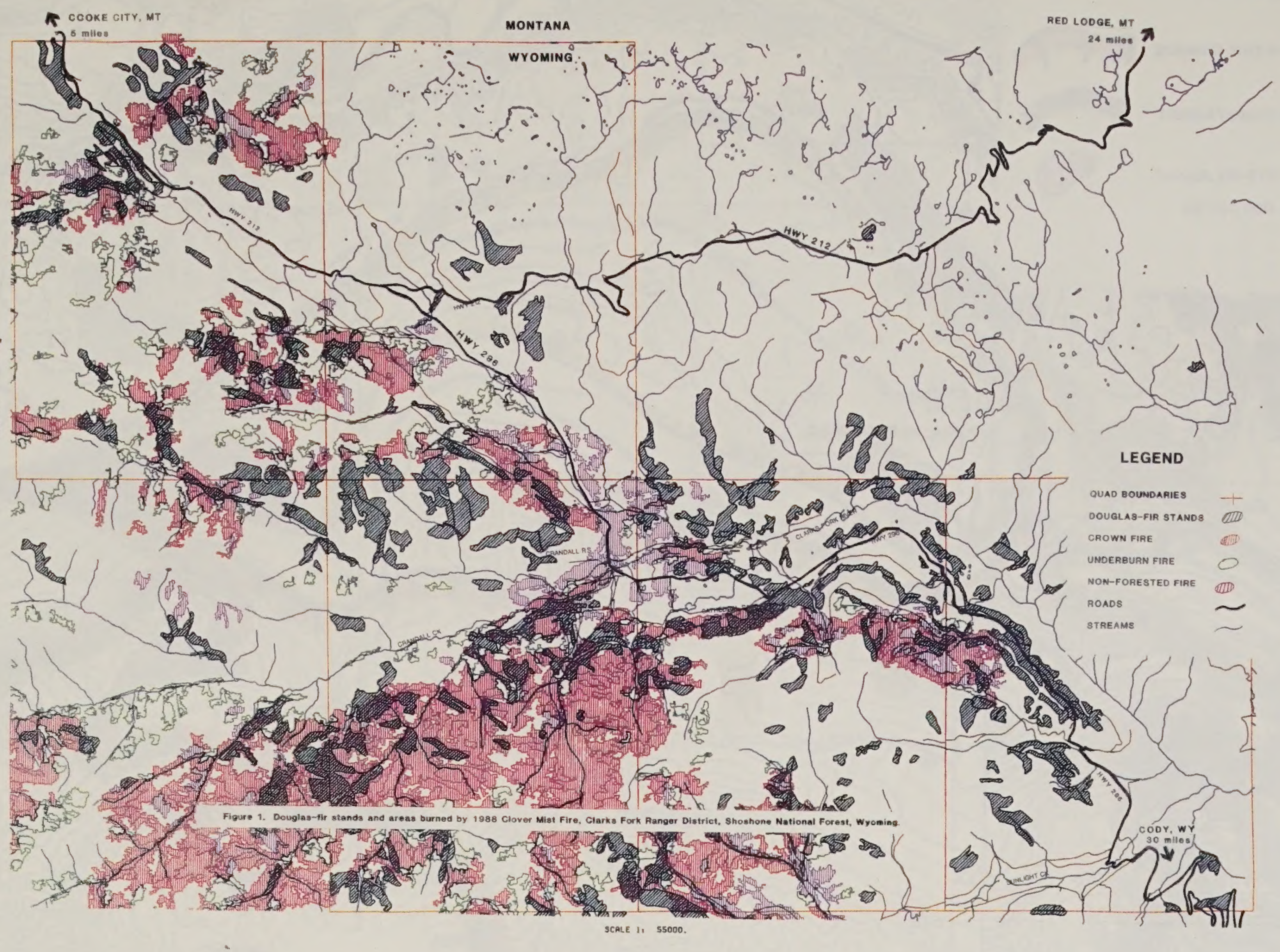

Figure 1. Douglas–fir stands and areas burned by 1988 Clover Mist Fire, Clarks Fork Ranger District, Shoshone National Forest, Wyoming.

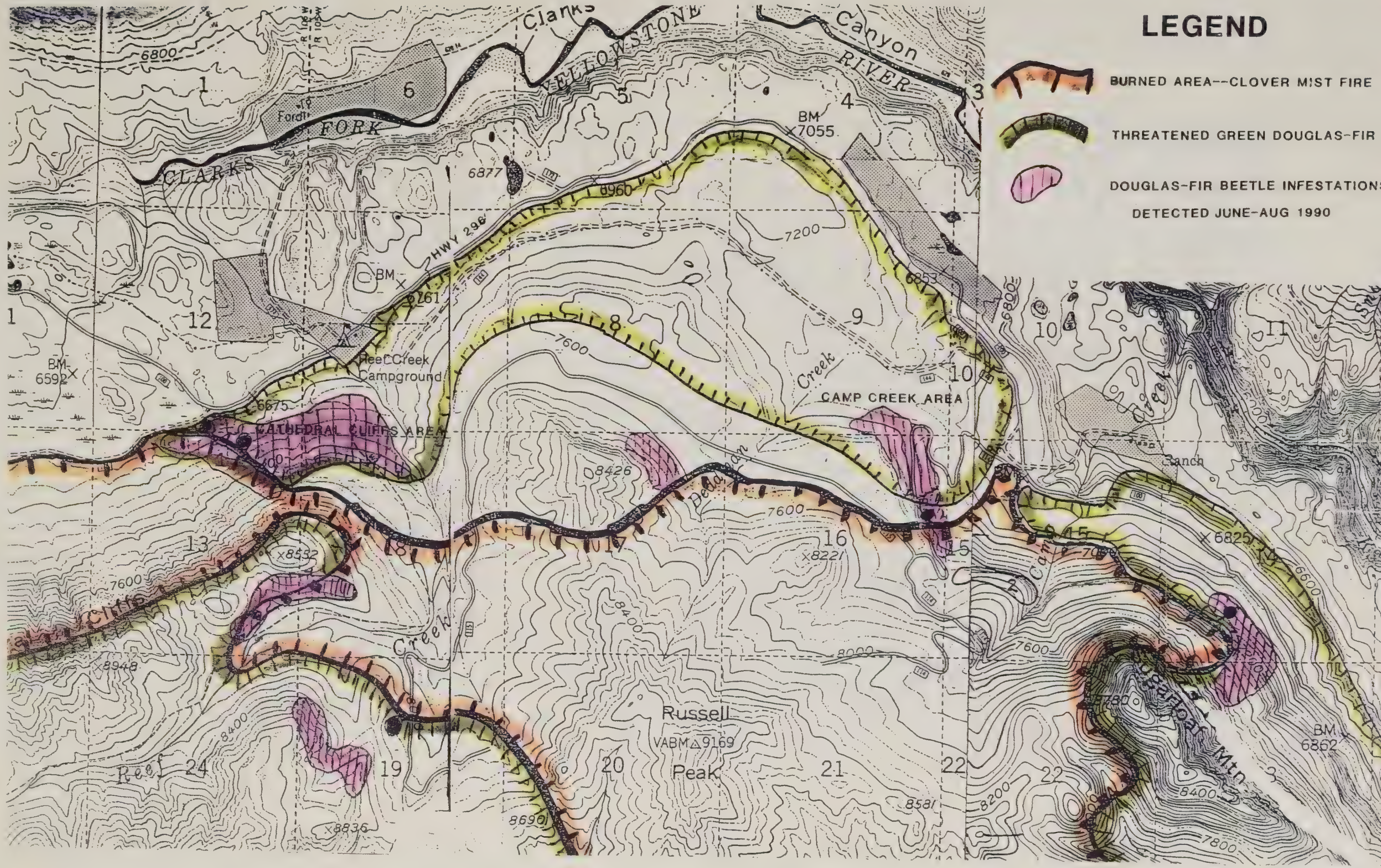

Figure 2. Generalized map of known Douglas-fir beetle infestations, Clarks Fork Ranger District, Shoshone National Forest, Wyoming, 1990.

METHODS

On 3 May 1990, 12 copper mesh emergence cages (2 sq. ft.) were stapled to Douglas-fir trees infested with DFB. DFB were collected from cages approximately weekly through early July to determine when beetle emergence occurred. Numbers of beetles were tallied and average beetle emergence per 36 sq. in. area was computed.

Bark samples (approximately 6 in. by 6 in.) were removed at a height of 5-7 ft. from the north and south sides of Douglas-fir trees infested by DFB at Camp Creek, Cathedral Cliffs, and the K-Z Ranch. DBH was recorded for each sample tree. Egg gallery starts (DFB attacks) were counted for each sample area. Bark samples were stored in plastic bags and transported to the office, where they were examined. Length and width of each sample was measured and the calculated area was used to adjust brood data to a 36 sq. in. basis. Inches of egg gallery were measured for each bark sample. Because of the thick phloem of many of the samples, as many as three layers of brood could be found. Phloem was shaved with a knife to locate all the brood in each sample. Numbers of DFB brood by life stage and presence of predators and parasites were tallied. Means were calculated for all variables measured.

Two felled trees, one at Camp Creek and one at Cathedral Cliffs, were sampled in a similar manner at several distances from the tree base to determine whether brood densities differed by tree height.

Seven felled trees (6 at Cathedral Cliffs, 1 at Camp Creek) were measured to the nearest foot for height of DFB mass attack. Tree diameter at the upper end of each infested bole was measured.

RESULTS

Adult DFB began emerging in early May and the majority emerged during June (Fig. 3). Beetles that emerged prior to 19 June primarily attacked scorched trees. Peak emergence occurred shortly thereafter and was reflected in the large number of DFB collected from emergence cages on 23 June. Green (unburned) trees were attacked after 19 June when suitable scorched trees were no longer readily available.

Cumulative emergence of DFB totalled 1,913 beetles from all caged bark areas. This is equivalent to an average of 79.7 beetles per sq. ft. or 19.9 beetles per 36 sq. in.

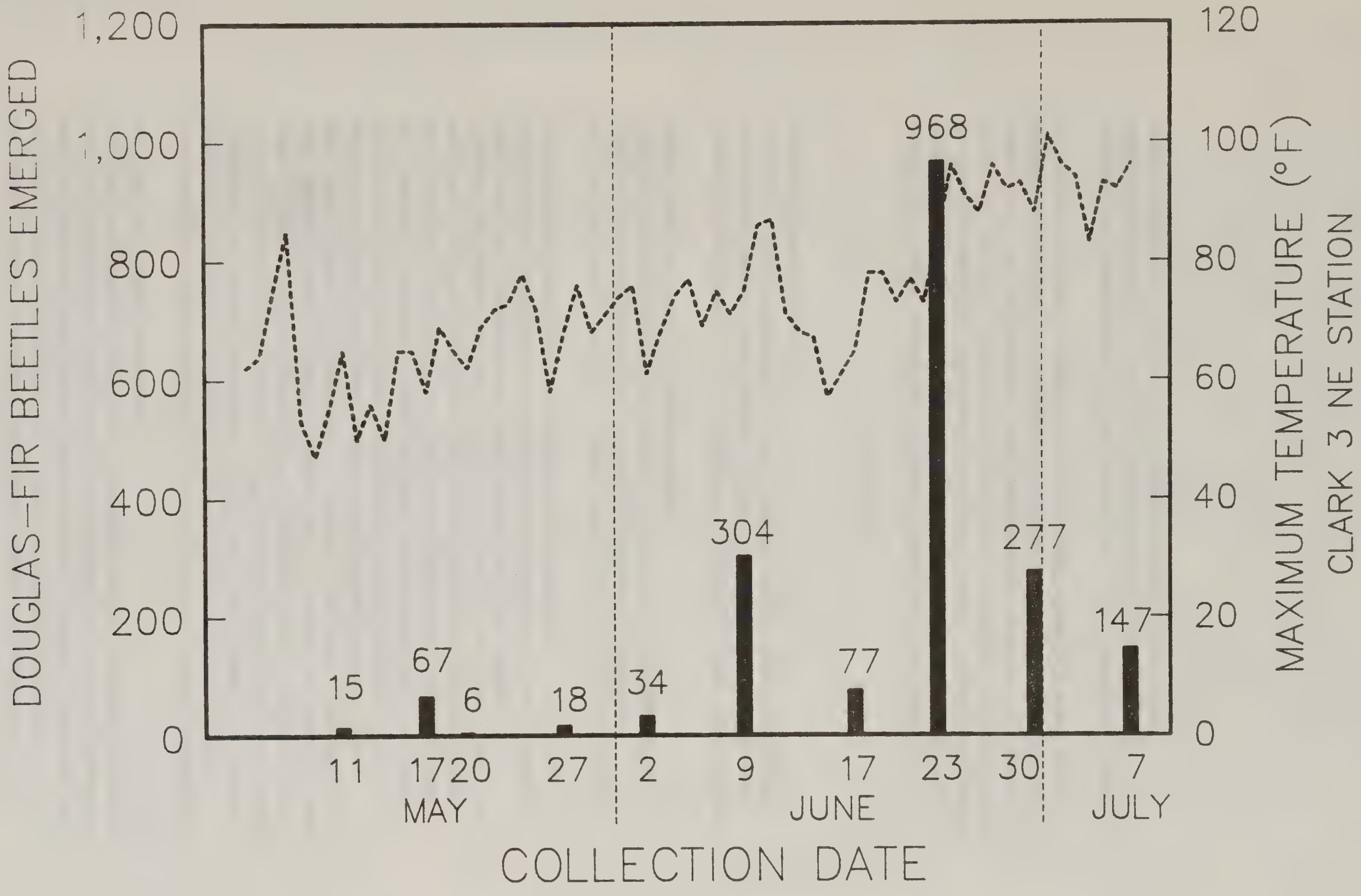

Figure 3. 1990 Douglas–fir beetle emergence from 12 cages (1 ft x 2 ft) on the Clarks Fork Ranger District, Shoshone NF, Wyoming.

DBH of infested trees sampled for brood density in fall 1990 averaged 22.8 in. and ranged from a mean of 19.6 in. at Camp Creek to a mean of 27.1 in. at the K-Z Ranch.

Mean brood production of DFB in bark samples (adjusted to 36 sq. in.) taken at 5-7 ft. summarized by site and sample direction (Table 1). Larvae, pupae, and new adults (callows) were abundant in samples and the proportion of each life stage present varied from sample to sample. One sample contained eggs only, but all other samples contained at least one of the other life stages. No unsuccessful egg galleries, i.e., those without larval mines and filled by pitch, were found in the samples. Brood densities were similar on north and south sides of trees. Samples from the Cathedral Cliffs area and timber sale were most developed with brood being predominately in the new adult stage. These sites contained scorched trees located near a large area of intensively-burned (completely blackened) trees. Samples from the K-Z Ranch site, located west of the Cathedral Cliffs sample sites and farther from the intensively burned areas, also were removed from scorched trees but brood was less developed, containing as many or more larvae as new adults. At Camp Creek, where infested trees were green (unburned) and located the farthest from totally burned areas of any of the sample locations, well over half the brood were in the larval or pupal stages. Total brood (all life stages) averaged 28 DFB per 36 sq. in. bark surface for all the samples. Densities of new adults averaged 14 per 36 sq. in. and ranged from a mean of 10 per 36 sq. in. at Camp Creek to 26 per 36 sq. in. at the Cathedral Cliffs area. Gallery starts averaged 1.8 per 36 sq. in. and gallery length averaged 20 in. per 36 sq. in. bark surface.

Few parasites and predators were detected in bark samples. The most abundant, the dipteran Medetera sp., averaged less than 1 (0.84) per 36 sq. in. bark surface. Clerid beetle larvae and immatures of the Coeloides sp. parasitic wasp were infrequently encountered, averaging 0.03 and 0.23 per 36 sq. in., respectively.

DFB brood production for the 2 trees sampled at several heights is summarized in Table 2. Samples were too few to run statistical analyses or draw any conclusions. However, it appears that gallery starts were greater at 20 and 30 feet than at 5 and 10 feet, but gallery length per 36 sq. in. was similar for all heights within a given tree. Total brood production appeared to be greatest at 5 feet. Few parasites and predators were found in any of the samples.

Height of DFB mass attack averaged ($\bar{x} \pm SD$) 34 ± 10 feet and ranged from 22 to 48 feet. Top diameter of the infested bole averaged ($\bar{x} \pm SD$) 18.96 ± 2.63 in. and ranged from 15.1 to 22.4 in.

Table 1. Mean DFB brood production per 36 sq. in. bark surface for samples taken at 5-7 ft.

	Direction	K-2 RANCH	CATHEDRAL CLIFFS	CATHEDRAL CLIFFS SALE	CAMP CREEK	ALL SITES
DBH (in.) ($\bar{x}$ ± SD)		27.12 ± 7.08	26.98 ± 3.44	21.44 ± 2.60	19.65 ± 2.18	22.80 ± 4.84
n		5	5	8	10	28
Eggs (No.) ($\bar{x}$ ± SD)	North	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
	South	0.00 ± 0.00	0.00 ± 0.00	2.62 ± 7.42	0.00 ± 0.00	0.78 ± 4.04
	Both	0.00 ± 0.00	0.00 ± 0.00	1.31 ± 5.25	0.00 ± 0.00	0.39 ± 2.86
Larvae (No.) ($\bar{x}$ ± SD)	North	20.52 ± 19.86	1.46 ± 1.03	3.84 ± 4.16	10.69 ± 7.82	9.12 ± 11.41
	South	12.01 ± 20.34	0.45 ± 0.52	4.32 ± 8.16	18.59 ± 11.64	10.46 ± 13.47
	Both	16.27 ± 19.48	0.96 ± 0.93	4.08 ± 6.26	14.64 ± 10.47	9.79 ± 12.38
Pupae (No.) ($\bar{x}$ ± SD)	North	0.23 ± 0.50	0.21 ± 0.42	0.40 ± 0.80	9.42 ± 11.85	3.68 ± 8.30
	South	1.32 ± 2.45	0.00 ± 0.00	1.31 ± 3.71	7.49 ± 6.98	3.41 ± 5.65
	Both	0.77 ± 1.76	0.11 ± 0.30	0.86 ± 2.64	8.45 ± 9.52	3.54 ± 7.03
New Adults (No.) ($\bar{x}$ ± SD)	North	12.49 ± 10.42	29.96 ± 20.92	14.32 ± 9.48	13.08 ± 12.72	15.84 ± 13.56
	South	11.98 ± 4.34	21.34 ± 12.84	17.32 ± 16.56	6.74 ± 6.36	13.01 ± 11.89
	Both	12.24 ± 7.53	25.65 ± 16.72	15.82 ± 13.12	9.91 ± 10.31	14.42 ± 12.71
Total Brood (No.) ($\bar{x}$ ± SD)	North	33.24 ± 25.12	31.64 ± 21.47	18.57 ± 8.72	33.19 ± 21.85	28.64 ± 19.51
	South	25.31 ± 18.66	21.79 ± 13.10	25.58 ± 14.98	32.82 ± 16.56	27.65 ± 15.70
	Both	29.28 ± 21.27	26.71 ± 17.28	22.08 ± 12.38	33.00 ± 18.89	28.14 ± 17.55
Gallery Starts (No.) ($\bar{x}$ ± SD)	North	1.29 ± 0.89	2.06 ± 0.65	2.15 ± 0.67	1.60 ± 0.85	1.79 ± 0.80
	South	1.00 ± 0.72	2.29 ± 0.42	1.76 ± 0.97	1.99 ± 0.70	1.80 ± 0.83
	Both	1.41 ± 0.78	2.18 ± 0.53	1.96 ± 0.83	1.80 ± 0.78	1.79 ± 0.81
Egg Gallery Lgth (in.) ($\bar{x}$ ± SD)	North	23.31 ± 15.31	24.18 ± 10.76	23.50 ± 11.16	13.94 ± 6.94	19.72 ± 11.01
	South	21.24 ± 10.96	22.78 ± 8.28	21.55 ± 8.96	18.47 ± 8.18	20.50 ± 8.58
	Both	22.28 ± 12.60	23.38 ± 8.57	22.53 ± 9.78	16.21 ± 7.74	20.12 ± 9.76
Clerids (No.) ($\bar{x}$ ± SD)	North	0.00 ± 0.00	0.00 ± 0.00	0.14 ± 0.38	0.07 ± 0.22	0.07 ± 0.24
	South	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
	Both	0.00 ± 0.00	0.00 ± 0.00	0.07 ± 0.27	0.04 ± 0.16	0.03 ± 0.17
Coeloides (No.) ($\bar{x}$ ± SD)	North	0.00 ± 0.00	0.45 ± 0.52	0.13 ± 0.36	0.12 ± 0.37	0.15 ± 0.36
	South	0.00 ± 0.00	1.10 ± 1.64	0.33 ± 0.65	0.16 ± 0.34	0.32 ± 0.76
	Both	0.00 ± 0.00	0.77 ± 1.18	0.23 ± 0.52	0.14 ± 0.34	0.23 ± 0.60
Medetera (No.) ($\bar{x}$ ± SD)	North	0.47 ± 0.65	0.82 ± 1.15	0.68 ± 1.18	0.75 ± 1.28	0.69 ± 1.08
	South	1.30 ± 1.81	0.65 ± 1.30	0.64 ± 0.73	1.25 ± 1.48	0.99 ± 1.30
	Both	0.89 ± 1.36	0.74 ± 1.14	0.66 ± 0.95	1.00 ± 1.37	0.84 ± 1.20

Table 2. Mean DFB brood production per 36 sq. in. bark surface for samples taken at several tree heights.

	CATHEDRAL CLIFFS			CAMP CREEK			
	5 FEET	15 FEET	30 FEET	5 FEET	10 FEET	20 FEET	30 FEET
DBH (in.)	27.4			20.6			
Eggs (No.) ($\bar{x} \pm SD$)	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Larvae (No.) ($\bar{x} \pm SD$)	1.22 ± 1.72	0.47 ± 0.66	1.42 ± 2.01	11.65 ± 14.85	4.02 ± 0.70	6.74 ± 1.38	19.48 ± 0.16
Pupae (No.) ($\bar{x} \pm SD$)	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	10.72 ± 3.63	5.52 ± 1.14	12.90 ± 8.90	6.92 ± 3.26
New Adults (No.) ($\bar{x} \pm SD$)	22.56 ± 2.64	11.76 ± 4.66	14.12 ± 0.14	19.85 ± 18.04	23.85 ± 14.57	15.45 ± 1.49	5.88 ± 3.10
Total Brood (No.) ($\bar{x} \pm SD$)	23.78 ± 0.91	12.22 ± 5.32	15.54 ± 2.16	42.22 ± 0.42	33.40 ± 12.72	35.10 ± 6.03	32.27 ± 6.52
Gallery Starts (No.) ($\bar{x} \pm SD$)	1.77 ± 0.78	0.94 ± 1.33	3.40 ± 0.56	1.91 ± 1.06	2.08 ± 0.39	3.64 ± 1.07	2.77 ± 1.15
Egg Gallery Lgth (in.) ($\bar{x} \pm SD$)	18.62 ± 0.00	28.68 ± 8.65	24.40 ± 2.33	12.94 ± 6.77	15.60 ± 2.91	14.42 ± 1.39	14.64 ± 10.27
Clerids (No.) ($\bar{x} \pm SD$)	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Coeloides (No.) ($\bar{x} \pm SD$)	0.00 ± 0.00	1.41 ± 0.66	0.48 ± 0.67	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Medetera (No.) ($\bar{x} \pm SD$)	1.22 ± 1.72	0.00 ± 0.00	0.95 ± 1.34	3.52 ± 0.04	0.45 ± 0.64	0.00 ± 0.00	0.00 ± 0.00

DISCUSSION

DFB adult emergence on the Shoshone National Forest in 1990 peaked later than that described for southern Idaho, where most adults fly during May, and a second peak in July is inconsequential (Furniss 1962). General field observations indicated that scorched trees near the fire boundary (e.g., Cathedral Cliffs) were attacked first (May to mid-June) in 1990. Later-emerging (mid-June to mid-July) adults had to search farther and eventually attacked green trees after scorched trees were fully occupied. This differs from the scenario documented following fire in southern Idaho, where the DFB population was unable to expand to green trees (Furniss 1965). DFB brood developed later at sites located farthest from the fire boundary; a large proportion of DFB brood was in larval and pupal stages in fall samples from the K-Z Ranch and Camp Creek. Most DFB broods in samples from Cathedral Cliffs were new (callow) adults by fall.

The greater proponderance of larvae and pupae in fall 1990 samples relative to fall 1989 samples, which were mostly new adults (Pasek 1990), suggests that adult emergence in 1990 may be more protracted and have bimodal peaks. Chansler (1968) suggested that an increase in the proportion of immatures relative to new adults present in early spring precedes a downward trend in DFB population numbers. Slow brood development may contribute to greater winter mortality, particularly for immatures. The density of new (callow) adults alone, averaging 14 per 36 sq. in. (56 per sq. ft.), still represents a very high population level relative to other documented epidemics (Chansler 1968; Schmitz and Rudinsky 1968).

Adult emergence in 1990 averaging 19.9 beetles per 36 sq. in. was greater than predicted from brood samples taken in fall 1989, which averaged 10.3 and 7.6 total brood per sample (6 in. x 6 in.) at Cathedral Cliffs and Squaw Creek, respectively (Pasek 1990). However, if the approximately 50% of samples that contained no brood are ignored, brood production in 1989 bark samples would have averaged ($\bar{x} \pm$ SD) 20.6 ± 18.4 and 13.2 ± 8.5 total brood per sample, respectively, at Cathedral Cliffs and Squaw Creek. Placement of emergence cages was intentionally biased toward trees that were most heavily infested.

Total brood averaging 28 DFB per 36 sq. in. (112 per sq. ft.) in fall 1990 samples taken at 5-7 feet, represents about a 1.5- to 2-fold increase in brood density. Based on an average of 1.8 gallery starts per 36 sq. in. (7.2 per sq. ft.), about 15 DFB were produced for every attack by a mated pair of beetles, or almost 8 DFB per attacking female by fall. McMullen and Atkins (1961) found maximum brood production occurs when gallery starts number 4-8 per sq. ft.

and gallery length is between 30 and 60 in. per sq. ft. area. Mean total gallery length was higher in the Shoshone National Forest samples, averaging 80 in. per sq. ft. area. This suggests that intraspecific competition is likely to be a limiting factor for population increase if brood density gets any higher.

Additional brood mortality may occur prior to adult emergence in spring and summer 1991, perhaps due to weather-caused mortality and predation by woodpeckers. Mortality from other factors is expected to be low because insect predator and parasite populations were low in fall samples. A significant decline in the DFB population is not anticipated prior to adult emergence in the absence of unusually harsh winter weather conditions.

Fewer DFB broods (and shorter galleries) appear to have been produced per attacking adult at heights of 10 feet or greater, given the greater number of gallery starts and fewer DFB brood per unit area. McMullen and Atkins (1961) reported an inverse relationship between mean gallery length and attack density. Patterns of brood density with bole height appear to differ from that reported by Furniss (1962) for an infestation in southern Idaho, where brood densities were greatest midway up (15-65 ft.) the infested portion of the bole and least in the basal zone. In fact, gallery lengths and brood densities taken at 5-7 ft. on the Shoshone National Forest in fall 1990 were almost identical to those reported for samples taken at 15-65 ft. on standing trees in southern Idaho. The high percentage of unsuccessful egg galleries reported for southern Idaho, particularly in the basal zone samples (about 25%), was not evident in samples from the Shoshone National Forest.

Similarly, the pattern of low DFB brood densities and an abundance of unsuccessful attacks found in fire-injured trees in southern Idaho (Furniss 1965) was not evident for the Shoshone National Forest situation. Further, DFB attacks were not limited to fire-blackened portions of boles on the Shoshone National Forest as they were in the fire-injured trees in southern Idaho. Trees on the Shoshone National Forest may be in poorer condition and therefore less resinous due to both fire injury and a continuing drought that began in 1988. Moisture stress has been implicated as a major factor in the susceptibility of Douglas-fir to attack (Furniss et al. 1981). Also, pitching of galleries is more likely to develop at low DFB attack densities. Apparently, the size of the DFB population on the Shoshone National Forest and the number of suitable scorched trees in 1990 were such that colonization occurred at high densities, thereby precluding the development of unsuccessful egg galleries.

Although brood densities at 5 feet appear to be greater than those at greater tree heights, fall 1990 samples taken at heights of 10 feet or more contained greater brood densities than samples taken at 5-7 feet in 1989. Additionally, height of DFB attack appeared to be greater in 1990 than in 1989. Although height of DFB attack was not measured in 1989, attack height was limited to about 10-15 feet because of excessive drying of bark and phloem in blackened trees above this level. Thus, the 1990 DFB population appeared to be utilizing about 2-3.5 times the bole space as the 1989 DFB population. The 34 ft. mean height of infested bole is approximately half the mean of 63 ft. reported for southern Idaho (Furniss 1962). Differences in infested height likely correspond to differences in total tree height at different locations; trees at Cathedral Cliffs and Camp Creek averaged 62 ft. and 50 ft., respectively, whereas the trees sampled in southern Idaho averaged 107 ft.

Combining the greater brood density and the greater amount of bole space utilized per tree in 1990, could represent a 3- to 7-fold increase in DFB numbers per infested tree. Because bole space was effectively fully utilized in 1990, the increased DFB population may be reflected as an increase in numbers of trees attacked in 1991 than as a further increase in DFB numbers occupying a given tree. Height of infestation might also increase, though, as fewer large diameter trees remain available for colonization in a given locality. Mean top diameter of infested bole equal to 19 in. was greater for trees measured on the Shoshone National Forest in 1990 than for windthrown trees measured in southern Idaho, which averaged 12 in. top infested diameter (Furniss 1962).

Actual numbers of infested trees in 1989 and 1990 are not known. During recent outbreaks in northern Idaho and western Montana, numbers of attacked trees increased by 4 or 5 times during the first couple years of DFB population buildup. A similar or somewhat greater increase in numbers of trees attacked is likely for 1991 on the Shoshone National Forest, Clarks Fork Ranger District, based upon increases in brood density and infestation height observed during fall 1990 relative to that observed in fall 1989.

ALTERNATIVES

Several methods are available to reduce populations of DFB and the resultant tree mortality. These pest management strategies may focus on the reduction of infested material, reduction of susceptible host material, or prevention of new attacks. The decision to use a particular method should be predicated on considerations of stand conditions, location, management objectives, economic factors, and other pertinent variables.

Alternative 1: **Salvage Harvesting** - Fell infested trees and remove them from the site for mill processing prior to adult DFB emergence. Stands with the highest percentages of large-diameter Douglas-fir should be given priority.

Where to use - Sites with the following conditions are appropriate: accessible to logging operations such as near existing roads or where roads can be readily constructed; less than 40% slope; where disturbance by man will not adversely affect special resource values; and in proximity to high value areas that need to be protected.

Advantages - Beetle broods can effectively be eliminated in small loci by removing all infested trees prior to beetle emergence. Beetle populations in larger groups can be significantly reduced. Salvaging provides a degree of protection to surrounding, uninfested trees by removing a nearby source of attacking beetles, recovers timber volume that otherwise would be lost, reduces fuel load, reduces subsequent hazard from falling trees and inaccessibility to large animals, reduces visual impact of dead and dying trees, and will encourage regeneration and greater diversity of size and age classes across the forest.

Disadvantages - Short implementation time is required; trees must be removed prior to adult emergence in the spring following attack. Adverse disturbance of the site and soil is possible. Salvaging removes tree cover in spots or at a density considered adverse aesthetically.

Alternative 2: **Tree Baits** - Commercially-available DFB tree baits containing attractant semiochemicals (aggregation pheromone) can be used to

concentrate beetles in trees that can be subsequently harvested. Baits are deployed just prior to beetle flight (May) and baited trees must be felled and removed or destroyed prior to the next adult emergence period (i.e., within one year).

Where to use - Ideal sites for placement of baits would be Douglas-fir trees in and around salvage operations. Baited areas must be suitable for harvest (Alternative 1) or mechanical control (Alternative 3). Baiting is likely to be most effective in areas where beetle populations are small, e.g., it is useful as a mop-up operation following removal of infested trees. Baiting is not suitable for large population centers; the native beetle population quickly overwhelms the baits in this situation.

Advantages - Baiting provides some degree of redirection of beetle attacks to trees where salvage can be implemented.

Disadvantages - Application is generally limited to sites accessible to harvest and where beetle populations are low and relatively isolated from larger population centers.

Alternative 3: **Mechanical Control** - Fell and buck infested Douglas-fir trees and treat them by burning, peeling the bark, or chipping the logs.

Where to use - Use in unroaded areas or on steep slopes that are accessible on foot (or horseback) to logging but where road building or skidding is undesireable. Sites where no logging company is interested in bidding on the timber or volume is too small to put up a sale also are appropriate.

Advantages - Much of the beetle brood can be eliminated even in the absence of a timber market. Mechanical control provides a degree of protection to surrounding, uninfested trees by removing a nearby source of attacking beetles. It also reduces subsequent hazard from falling trees and inaccessibility to large animals, reduces visual impact of dead and dying trees, and will encourage regeneration and greater diversity of size and age classes across the

forest. Potential for site and soil disturbance is less than for Alternative 1.

Disadvantages - Mechanical control is labor intensive, does not recover value and volume from trees, leaves a high fuel load on the site, removes tree cover, and requires a short implementation time; trees must be treated prior to adult emergence in the spring following attack.

Alternative 4: **Trap Trees** - Green trees can be felled and left on the site to attract beetles. Felled logs are sprayed with carbaryl in April or May, just prior to the beetle attack period, so that beetles will be killed as they enter the logs. Tree baits can be used on felled logs to increase their attractiveness to beetle attack.

Where to use - Use in small infestation pockets where salvaging, mechanical control, or reentry is impractical. Also use in unroaded areas or on steep slopes that are accessible on foot (or horseback) to logging but where road building or skidding is undesirable. Sites where no logging company is interested in bidding on the timber or volume is too small to put up a sale also are appropriate. Trap trees may be used as a tool to mop-up a population following salvaging.

Advantages - Use of trap trees concentrates beetle attack away from trees where protection is desired, kills beetles, does not require sale preparation and administration, can be used on sites with steep slopes or where roads do not exist and are not desirable, and is not as labor intensive as mechanical control.

Disadvantages - Use of trap trees does not recover value and volume from trees, leaves a high fuel load on the site, and removes tree cover.

Alternative 5: **Silvicultural Treatment** - To reduce susceptibility in green stands, basal area should be reduced below 80% of normal stocking (Furniss et al. 1981). Mature and overmature stands of Douglas-fir can be harvested. Younger stands should be thinned

periodically to improve vigor and reduce moisture stress.

Where to use - This is a preventative treatment that should be considered as an ongoing part of the regular timber program. Due to limited staffing and funding, this alternative is not suitable during an epidemic where resources are better spent on other options.

Advantages - Silvicultural treatment reduces susceptibility of stands to beetle attack, which may limit tree mortality and infestation size in the event of a future increase in beetle population.

Disadvantages - This alternative is not suitable for sites where harvesting activity is not desirable, such as in wilderness, on steep slopes, or where visual quality would be adversely impacted.

Alternative 6: **Protection of High Value Trees** - Prior to beetle flight in early spring (April or May), the boles of valuable trees can be sprayed with carbaryl to prevent DFB attack.

Where to use - This method would be appropriate for use in and around campgrounds and private homes. Trees must be of high value. Insecticide application is not effective for trees that have already been infested.

Advantages - Insecticide application provides a degree of protection not currently available through other mitigation strategies. Carbaryl has a low mammalian toxicity and low residual activity, which means it remains in the environment for a short period of time.

Disadvantages - Efficacy for protection of Douglas-fir needs to be demonstrated by a test prior to operational usage. Material is toxic to other insects as well as to DFB. Many citizens have concerns about environmental contamination and safety. Insecticide application does not effectively reduce the existing beetle population, is expensive if very many trees are treated,

and size of treatment areas need to be small due to cost and labor considerations.

Alternative 7: **Repellents** - A granular controlled-release formulation of the DFB antiaggregative pheromone, 3-methyl-2-cyclohexen-1-one (MCH), can be broadcast or aerially applied to stands where protection is desired. This alternative currently requires an experimental use permit (cleared by EPA through 5/93); registration of the material with EPA is not yet completed.

Where to use - The method is most suited for high value and inaccessible stands that are not currently infested but are threatened by nearby beetle populations.

Advantages - MCH is nontoxic; it is a natural chemical that is produced by DFB. Use of MCH is a promising method of preventing new attacks.

Disadvantages - MCH does not directly reduce the existing beetle population. Granular application distributes plastic pellets into the environment. Availability of the material may be a problem. MCH is not yet registered and has not yet been tested for protection of standing, green trees (only for blowdown situations).

Alternative 8: **Do Nothing** - Accept tree mortality caused by DFB as a natural phenomenon.

Where to use - Use where other control alternatives cannot be effected or is not desired. This may be the only viable alternative for infested stands that are inaccessible, areas designated as wilderness, and sites where the visual and erosive impacts of harvesting are a major concern.

Advantages - No unnatural site disturbance or introduction of foreign materials into the environment will occur. Change in vegetation follows a natural event.

Disadvantages - The no action alternative allows the beetle population to continue to increase and threaten additional sites. Tree volume and value is lost, visual quality is adversely affected by dying and

dead trees, fuel load increases, tree hazard increases, inaccessibility to large animals increases with time as trees fall over, and tree regeneration is inhibited due to shading by remaining dead trees and lack of seedbed preparation.

RECOMMENDATION

Alternative 1 should be considered wherever feasible and economical within the suitable timber base to remove as many infested trees as possible. Newly-attacked trees need to be located each summer during the course of the epidemic and salvage sales need to be put in each year for several years until DFB populations are satisfactorily reduced at sites where management objectives would otherwise be adversely affected.

Alternative 2 may be appropriate for some sites where DFB can be lured a short distance in a particular direction so that infested trees are accessible for harvesting. Successive baiting and salvaging may be needed.

Alternative 5 should be considered for long-range management planning to increase the health of forest stands and reduce susceptibility to DFB attack.

Alternative 8 may be selected of necessity in much of the Clarks Fork Ranger District because of the extensive areas of wilderness affected by the Clover Mist Fire, the presence of inaccessible areas, the concern for visual and erosive impacts of harvesting options, and the constraints on time and manpower available to treat damaged sites.

Land managers need to develop site-specific plans to manage stands to reduce the impact of DFB where feasible. Alternatives should be carefully weighed in relation to site-specific characteristics. Forest Pest Management personnel will continue to assist in reassessing DFB population and damage levels as needed during the course of the infestation.

District and Forest personnel are commended for their efforts thus far in attempting to mitigate DFB populations in key forest management areas.

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